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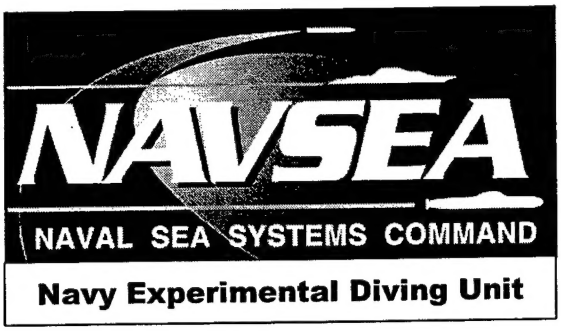

EVALUATION OF DUI "JACKET" BUOYANCY COMPENSATOR

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19. ABSTRACT: **NEDU was tasked to conduct a survey of commercially available buoyancy compensators (BCs), and perform testing to determine which BC perform satisfactorily. Buoyancy compensator evaluation was conducted in three phases. Phase I, receipt inspection of the buoyancy compensator, technical review of the manufacturer supplied documentation (instructions / repair manuals), diver orientation, and Test Pool Evaluation (BC surface floating attitudes if used as a Life Jacket). No failure mode analysis was conducted. Phase II consisted of buoyancy / lift capacity testing in the Test Pool at 15 fsw. Phase III consisted of manned dives in the Gulf of Mexico to test diver buoyancy control and operational characteristics.**

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INTRODUCTION

Navy Experimental Diving Unit (NEDU) is tasked[1] to conduct surveys of commercially available buoyancy compensators (BCs), and perform testing to determine which BCs perform satisfactorily in accordance with references (2) and (3). All buoyancy compensators that meet the above requirements will be candidates for recommendation to the Authorized for Navy Use (ANU) list. The purpose of this technical report is to determine if DUI "Jacket" buoyancy compensator meets those requirements.

METHODS

GENERAL

Each BC was tested and evaluated in three different environments; Phase I (Bench Test), Phase II (Controlled Environment (Test Pool/Ocean Simulation Facility (OSF)), and Phase III (Open Ocean Diving). While bench testing, each BC was evaluated by two qualified U.S. Navy divers for completeness and adequacy of maintenance manuals and technical documentation, skill level required to perform routine repair and maintenance, operation of the integrated weight belt and the operation of all BC components. In a controlled environment, each BC was tested and evaluated for buoyancy and lift capability. While performing open water dives, each BC was used and evaluated by qualified U.S. Navy divers in a single SCUBA tank configuration to a minimum of 30 fsw (9.4 msw). The conversion for msw is in accordance with reference (4).

EXPERIMENTAL DESIGN AND ANALYSIS

All BCs tested were off the shelf items; three sizes were tested, (i.e., medium, large and X-large). The Task Leader or assigned representative was present during the set-up and post-dive procedures on all BCs.

Phase I testing:

- Each model BC was evaluated by two qualified U.S. Navy divers for ease of operation and maintenance procedures.
- Average cost, from five different suppliers was acquired.

Specific comments from evaluators were compiled and documented.

Phase II testing:

- All different size BCs were tested to 15 fsw (4.7 msw) utilizing the Test Pool. Each BC was fully inflated, recording the average lift capacity.

Phase III testing:

Each different size BC were evaluated during open water dives. A series of evaluation dives were conducted to a minimum depth of 30 fsw. Divers completed a

human factor questionnaire after each dive. A set of descriptive statistics of the responses and specific comments were complied.

EQUIPMENT AND INSTRUMENTATION

No special or proprietary tools were required to perform routine maintenance or repair on the BCs.

a. Phase I: During bench testing, the following equipment was used:
   (1) Fully charged SCUBA bottle and an approved regulator (used to supply low-pressure air to perform equipment checks)
   (2) Manufacturer's instructions and maintenance manual
   (3) Miscellaneous hand tools and adapter fittings
   (4) Weights (soft or molded)

b. Phase II: During Test Pool testing the following equipment was used:
   (1) Calibrated Viking spring scale model 895, 0 to 50 pounds (0 to 22.68 kg) manufactured by Hanson in Shubuta, Mississippi.
   (2) Lanyards, spinnaker shackles, and weight as appropriate to anchor BCs to deck in Test Pool
   (3) Fully charged SCUBA bottle and an approved regulator (used to supply low-pressure air)
   (4) Personnel as required
   (5) Weights

c. Phase III: During at sea testing, the following equipment was used:
   (1) Fully charged SCUBA bottle, approved regulator and all other personnel diving equipment needed to perform a SCUBA dive
   (2) Personnel as required
   (3) At sea diving platform

PROCEDURES

BC evaluation was conducted in three phases: (1) receipt inspection and technical review of manufacturer supplied documentation, (2) Test Pool evaluation (buoyancy/lift capacity at 15 fsw), (3) open water dives to test buoyancy control and operational characteristics.

a. Phase I testing began with a review of the following:
   (1) Completeness and adequacy of the maintenance manuals and technical documentation
   (2) Requirements for special or proprietary tools
   (3) Skill level required to perform routine repair and maintenance
   (4) Operation of integrated weight system

(5) Operation and activation of all BC components
(6) Ease of assembly in single tank configuration
(7) Unit price

A technical documentation and operational function worksheet was completed by each qualified diver assigned, and returned to the Task Leader.

b. Phase II Testing: Buoyancy/lift capacity of the units were tested in the Test Pool at a depth of 15 fsw. All divers participating in the study were required to familiarize themselves with the contents of the user's manual, to include location of controls on the BC and donning procedures.

A calibrated Viking spring scale model 895 was attached to the deck via a 100 lbs. clump in the Test Pool to measure buoyancy. Each BC tested was attached to the scale and tested in the Test Pool at 15 fsw. The buoyancy was measured and documented; at a minimum, each BC was required to provide 10 lbs. of positive lift as outlined in reference (2). The BC was also tested for leaks at depth.

c. Phase III Testing: Manned open water dives were conducted to a minimum depth of 30 fsw to determine each BC's swim characteristics. Results were documented using a diver's questionnaire.

RESULTS

PHASE I

The inspection of the manufacturer's supplied documentation on the use, service, parts, technical aspects and exploded views/diagrams was excellent. Documentation fails to include a parts list or technical specifications within the supplied buoyancy compensator manual, but are available from the manufacturer upon request. There were no requirements for special or proprietary tools needed. Skill level required to perform routine maintenance should be at least a second class diver or above. The integrated weight system weights were secure and easy to operate the release mechanism. The operation and activation of all BC components were easy to operate. There were no problems assembling the single tank configuration, there was no twin tank configuration. The DUI "Jacket" BC has an integrated weight belt system that can be removed and ditched from the BC by the diver in case of emergency[4]. This system is easy to use and easy to reinstall onto the BC. The weight module pockets are designed to hold a maximum of 10 lbs. of molded or soft weights in each pocket for a total onboard weight capacity of 40 lbs.

The average manufacturer's suggested price per unit (X-Small – X-Large) is $358.

PHASE II

The DUI "Jacket" BC in the single tank configuration averaged 32.5 lbf (Medium), 35.5 lbf (Large), 43.0 lbf (X-Large) of positive lift at 15 fsw (see Table 1). The measured buoyancy of the DUI "Jacket" BC was approximately 7.1% less than the 35 lbf (Medium), 15% less than 42 lbf (Large) and 10% less than the 48 lbf (X-Large) quoted by the manufacturer. However, that difference might have been due to differing test conditions, procedures, or depth.

No twin tank configuration was tested. At the time of testing, a twin tank configuration was not available.

PHASE III

During the manned evaluation of the DUI "Jacket" BC, 14 divers tested the "Jacket" BC in a single tank configuration to depths ranging from 30 to 100 fsw. On a scale of 1 – 6 (4.0 being the minimum mark for an overall acceptable score), this BC scored a rating of 4.79 in the single tank configuration.

CONCLUSIONS

During testing, two major items of note were encountered. First, in accordance with the manufacturer's technical manual and Maintenance Requirement Card (MRC) MIP 5921/023 R-1, the cylinder band strap must be wet prior to installation of the tank (single configuration). If this was not done, the bottle had a tendency to slip down and out of the BC, which could lead to the loss of the diver's air supply. Second, approximately 35% of the divers reported that this BC has too many straps, and accessory buckles.

RECOMMENDATIONS

Based on the testing and evaluation in accordance with reference (3) and reported in Tables (1) and (2), we recommend that the DUI Model name "Jacket" (P/N: Small, 290602, Medium 290603, Large 290604, X-Large 290605) be authorized for Navy use in the single tank configuration. Prior to each diving day, PMS MIP 5921/023 R-1 must be completed. No surface floating attitude testing was conducted, as per manufacturer's supplied documentation; therefore we do not recommend this BC be used as a life preserver.

Table 1. DUI "Jacket" Buoyancy Compensator Pull Test Data Sheet

DUI "Jacket" Single Tank Configuration					
NO.	NOMENCLATURE	SIZE	BUOYANCY (LBF)	DEPTH	INFLATION METHOD
1	DUI "Jacket"	M	32.5 lbf	15 FSW	LP WHIP FROM SCUBA BOTTLE
2	DUI "Jacket"	L	35.5 lbf	15 FSW	LP WHIP FROM SCUBA BOTTLE
3	DUI "Jacket"	LG	43 lbf	15 FSW	LP WHIP FROM SCUBA BOTTLE

Table 1. Each size BC was tested to 15 fsw (4.7 msw) utilizing the Test Pool. Each BC was fully inflated three times in the single tank configuration, recording the average lift capacity.

Table 2. Human Factors Evaluationof the DUI "Jacket" Buoyancy Compensator in Single Tank Configuration.

DUI "Jacket" Single Tank Configuration										
	#8	#9	#10	#11	#12	#13	#14	#15	#16	
QUESTIONNAIRE #	Comfort	Mobility	Donning & Doffing	Neutral Buoyancy	Location of Controls	Operating Controls	Water Drag	Feel Comfortable	Overall Rating	AVERAGE
1	4	4	3	4	4	4	4	4	3	3.78
2	5	5	5	5	5	4	6	5	5	5.00
3	6	5	6	4	5	5	5	6	6	5.33
4	6	6	6	5	5	6	6	6	6	5.78
5	2	4	4	4	1	4	6	4	3	3.56
6	4	4	4	5	4	4	4	4	4	4.11
7	4	4	4	4	4	4	4	4	4	4.00
8	6	6	6	6	6	5	6	6	6	5.89
9	4	4	4	4	4	4	4	4	4	4.00
10	5	5	4	6	6	4	6	5	6	5.22
11	6	6	6	6	6	6	6	6	5	5.89
12	5	5	5	5	5	5	4	5	5	4.89
13	4	5	2	6	5	4	5	4	4	4.33
14	5	6	5	5	5	5	6	5	5	5.22
QUESTION AVERAGE	4.71	4.93	4.57	4.93	4.64	4.57	5.14	4.86	4.71	4.79
								Overall Average		4.79

Table 2. A series of open water evaluation dives per tank configuration were conducted to a minimum depth of 30 fsw (9.4 msw). Divers completed a human factors questionaire after each dive. A set of descriptive statistics of the responses and specific comments were complied. The BCs scored on a scale of 1-6 scale (4.0 being the minimum mark for an overall acceptable score) (1 = poor, 4 = adequate, 6 = excellent).

REFERENCES

1. Commander, Naval Sea Systems Command, Task Assignment 98-10, *Commercial Diving Equipment Test and Evaluation*, Dec 97.
2. NAVSEA ltr Ser: OOC32/3265 dated 21 July 1989
3. R. W. Mazzone, *Procedure for the Evaluation of Commercially Available Buoyancy Compensator's (Unmanned/Manned),* NEDU TP98-01, Navy Experimental Diving Unit, January 1998.
4. Naval Sea Systems Command, *U.S. Navy Diving Manual, Vol. #5*, Rev. 4, NAVSEA SS521-AG-PRO-010, 20 Jan 99. Chapter 7-2.3.4, page 7-9.